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(54) EFFICIENT TRACKING OF PERSONAL DEVICE LOCATIONS

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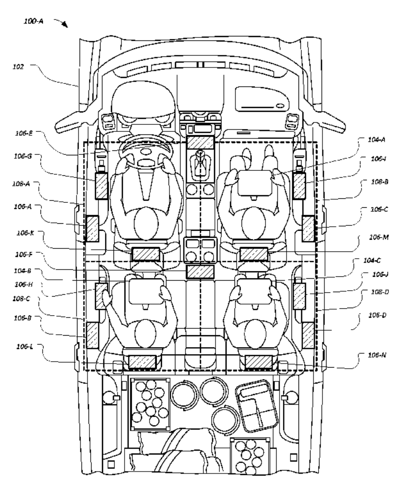
(57) **ABSTRACT**

A system may include zones associated with respective seating positions of a vehicle and in-vehicle components each associated with at least one of the zones. An in-vehicle component may identify a personal device associated with the zone of the in-vehicle component by identifying a personal device associated with the zone of the in-vehicle component by determining average signal strength between the personal device and the in-vehicle components of each zone, and identifying for which zone the average signal strength is highest, and sending a notification to the personal device responsive to a detected user interaction. A method may include detecting user interaction to an in-vehicle component of a zone; acquiring signal strength intensity information of personal devices from other in-vehicle components of the zone; calculating average signal strengths of the personal devices to the in-vehicle components; associating one of the personal devices to the zone as having a highest average signal strength to the in-vehicle components of the zone; and sending a notification to the one of the personal devices.

20 Claims, 4 Drawing Sheets



(58) **Field of Classification Search**
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See application file for complete search history.

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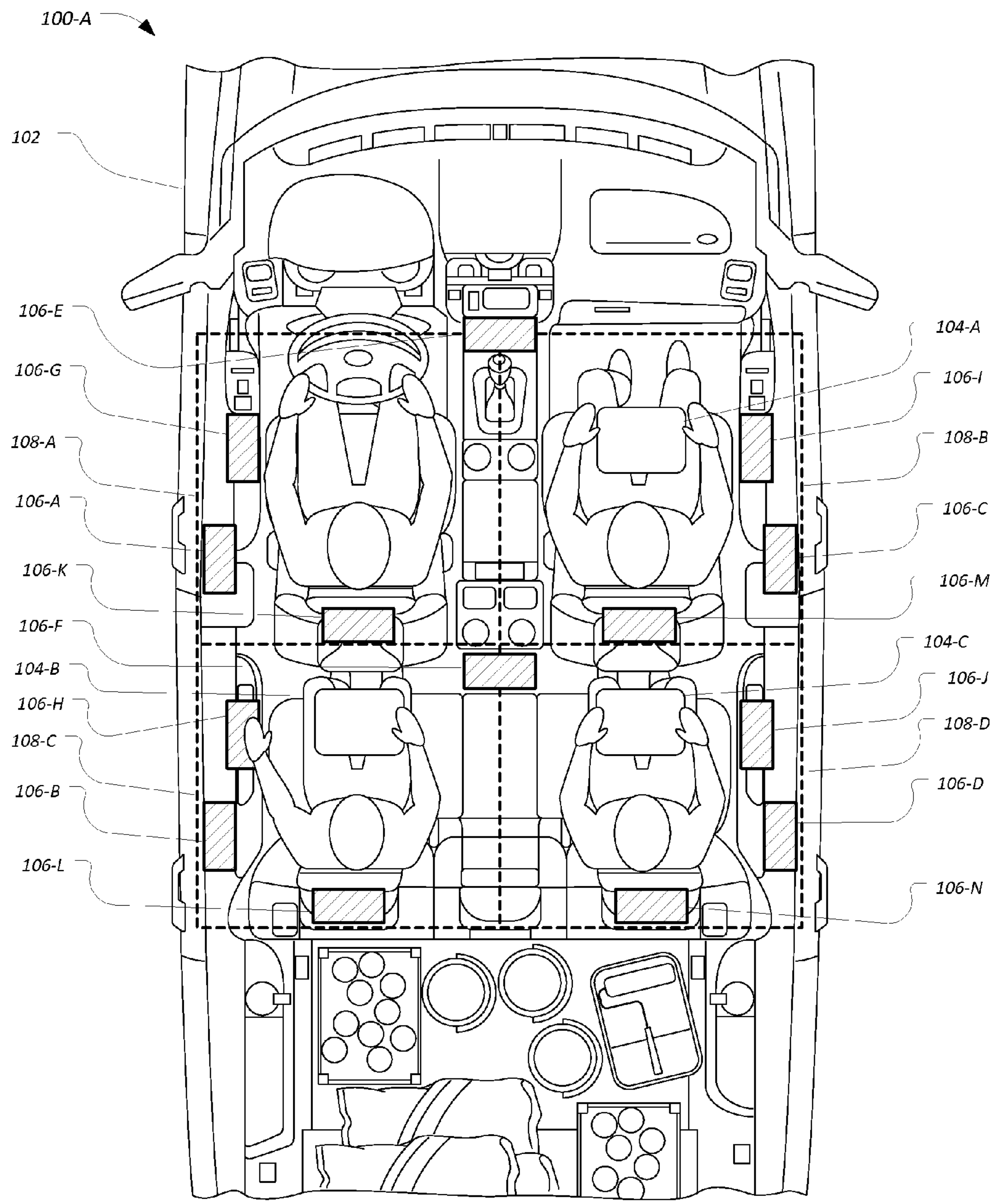
100-A
102
106-E
106-G
108-A
106-A
106-K
106-F
104-B
106-H
108-C
106-B
106-L
104-A
106-I
108-B
106-C
106-M
104-C
106-J
108-D
106-D
106-N

FIG. 1A

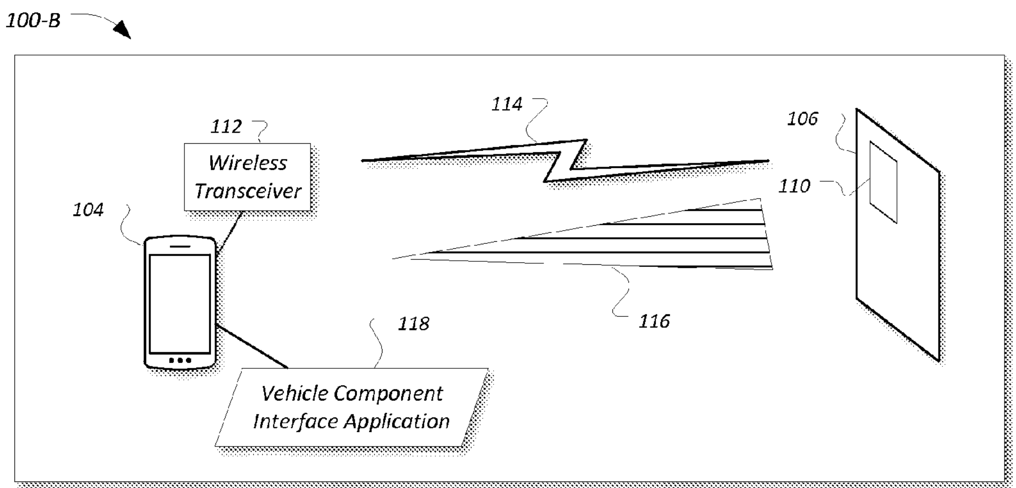
100-B
112
Wireless Transceiver
114
106
110
104
118
116
Vehicle Component Interface Application

FIG. 1B

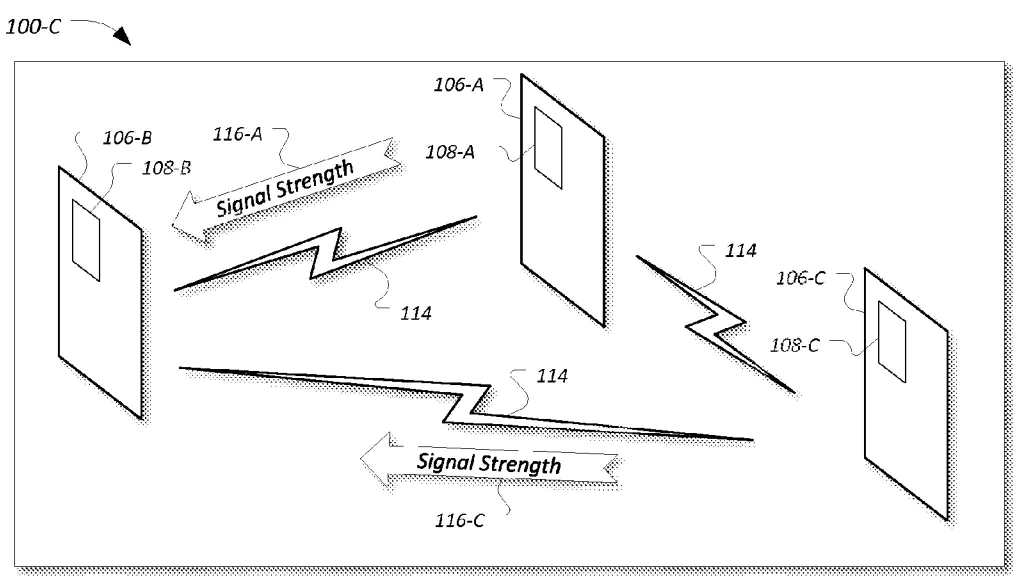
100-C
106-A
106-B
116-A
108-A
108-B
Signal Strength
114
106-C
114
108-C
114
Signal Strength
116-C

FIG. 1C

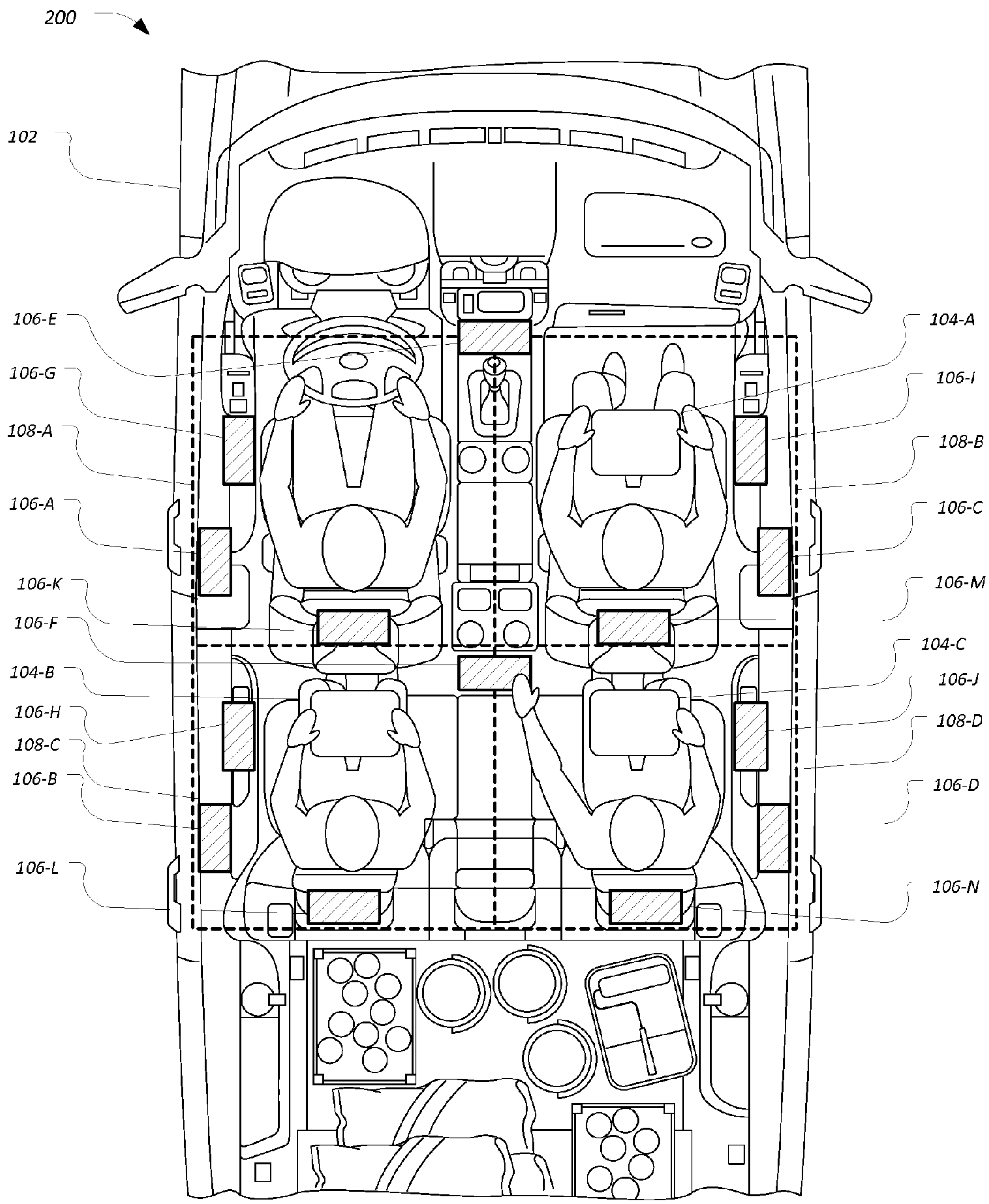
200
102
106-E
106-G
108-A
106-A
106-K
106-F
104-B
106-H
108-C
106-B
106-L
104-A
106-I
108-B
106-C
106-M
104-C
106-J
108-D
106-D
106-N

FIG. 2

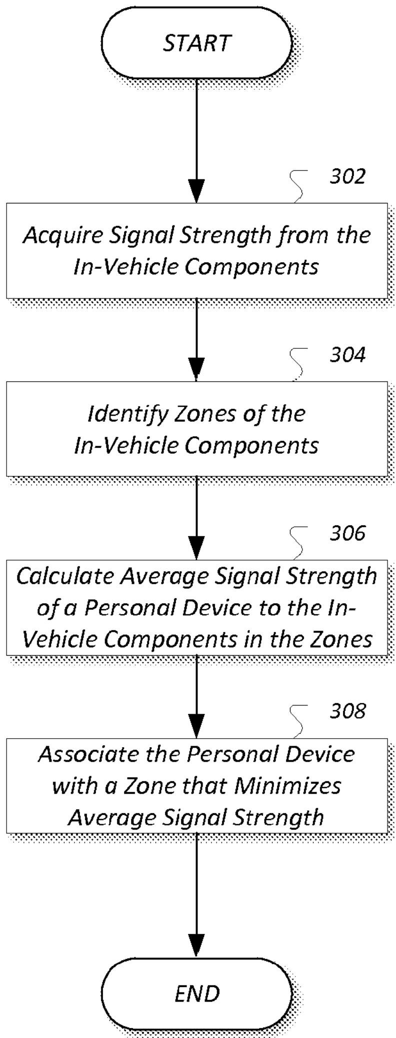
START
302
Acquire Signal Strength from the In-Vehicle Components
304
Identify Zones of the In-Vehicle Components
306
Calculate Average Signal Strength of a Personal Device to the In-Vehicle Components in the Zones
308
Associate the Personal Device with a Zone that Minimizes Average Signal Strength
END

FIG. 3

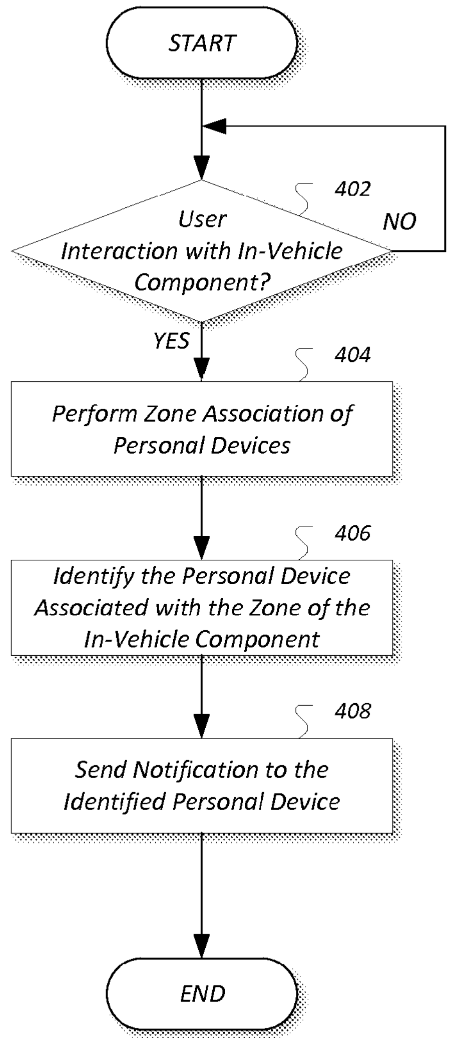
START
402
User Interaction with In-Vehicle Component?
NO
YES
404
Perform Zone Association of Personal Devices
406
Identify the Personal Device Associated with the Zone of the In-Vehicle Component
408
Send Notification to the Identified Personal Device
END

FIG. 4

EFFICIENT TRACKING OF PERSONAL DEVICE LOCATIONS

TECHNICAL FIELD

Aspects of the disclosure generally relate to efficient tracking of personal device locations within the vehicle cabin.

BACKGROUND

Sales of personal devices, such as smartphones and wearables, continue to increase. Thus, more personal devices are brought by users into the automotive context. Smartphones can already be used in some vehicle models to access a wide range of vehicle information, to start the vehicle, and to open windows and doors. Some wearables are capable of providing real-time navigation information to the driver. Device manufacturers are implementing frameworks to enable a more seamless integration of their brand of personal devices into the driving experience.

SUMMARY

In a first illustrative embodiment, a system includes vehicle seating having zones associated with seating positions; and in-vehicle components, each associated with at least one of the zones, one of the in-vehicle components programmed to identify a personal device associated with the zone of the in-vehicle component by determining average signal strength between the personal device and the in-vehicle components of each zone, and identifying for which zone the average signal strength is highest, and send a notification to the personal device responsive to a detected user interaction.

In a second illustrative embodiment, a system includes an in-vehicle component, associated with a zone seating position of a vehicle, programmed to acquire wireless signal strength intensity information of a personal device from other in-vehicle components; identify zones of the other in-vehicle components; calculate an average signal strength of the personal device to the in-vehicle components in each of the zones; and associate the personal device with the zone having a highest average signal strength to the personal device.

In a third illustrative embodiment, a computer-implemented method includes detecting user interaction to an in-vehicle component of a zone; acquiring signal strength intensity information of personal devices from other in-vehicle components of the zone; calculating average signal strengths of the personal devices to the in-vehicle components; associating one of the personal devices to the zone as having a highest average signal strength to the in-vehicle components of the zone; and sending a notification to the one of the personal devices.

In a fourth illustrative embodiment, a system includes vehicle seating having zones associated with seating positions; and in-vehicle components, each associated with at least one of the zones; and a personal device located in one of the zones and programmed to identify in-vehicle components associated with the zone of the personal device by determining average signal strength between the personal device and the in-vehicle components of each zone, and identifying for which zone the average signal strength is highest, and receive a notification responsive to a user interaction detected by one of the in-vehicle components of the zone.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A illustrates an example system including a vehicle having a mesh of in-vehicle components configured to interact with vehicle occupant and user devices;

FIG. **1**B illustrates an example in-vehicle component equipped with a wireless transceiver configured to facilitate detection of and identify proximity of the personal devices;

FIG. **1**C illustrates an example in-vehicle component requesting signal strength from other in-vehicle components of the vehicle;

FIG. **2** illustrates an example system including a vehicle occupant interacting with a centrally-located in-vehicle component;

FIG. **3** illustrates an example process for using zone-coding of the in-vehicle components to assign personal devices to the zones of the vehicle; and

FIG. **4** illustrates an example process for activating the personal device associated with the zone of the in-vehicle component with which a user is interacting.

DETAILED DESCRIPTION

As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. The figures are not necessarily to scale; some features may be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present invention.

As smartphones, tablets, and other personal devices become more powerful and interconnected, there is an opportunity to integrate more intelligence and sensing into components of the vehicle interior. Traditional vehicle interior modules, such as reading lights or speakers, may be enhanced with a communication interface (such as Bluetooth Low Energy (BLE)). These enhanced modules of the vehicle interior may be referred to as in-vehicle components. The vehicle occupants may utilize their personal devices to control features of the in-vehicle components by connecting their personal devices to the in-vehicle components over the communications interface. In an example, a vehicle occupant may utilize an application installed to the personal device to turn the reading light on or off, or to adjust a volume of the speaker.

In many cases, it may be desirable for a vehicle occupant to be able to control the in-vehicle components that relate to the seat in which the vehicle occupant is located. A zone-coding approach may be utilized to allow the in-vehicle components to identify which personal devices should control which in-vehicle components. In the zone-coding approach, the vehicle interior may be subdivided into zones, where each zone relates to a seating position of the vehicle. Each of the in-vehicle components may be assigned to the zone or zones in which the respective in-vehicle components are located and/or control. The personal devices may receive signal strength information received from the communication interface of the in-vehicle components. Conversely, the in-vehicle components may receive signal strength information from the in-vehicle devices to the personal device of the vehicle occupant using the communication interfaces in-vehicle components. Using the signal strength information, the personal device may be assigned to the zone of the vehicle in which the average signal strength between the personal device and the in-vehicle components is the highest. Accordingly, when one of the in-vehicle components receives an indication of a user interaction with its controls, the in-vehicle component may send a notification to the personal device that is associated with the same zone as the in-vehicle component with which the user is interacting. Further aspects of the zone-coding approach are discussed in detail below.

FIG. **1**A illustrates an example system **100** including a vehicle **102** having a mesh of in-vehicle components **106** configured to interact with users and personal devices **104** of the users. The system **100** may be configured to allow the users, such as vehicle occupants, to seamlessly interact with the in-vehicle components **106** in the vehicle **102** or with any other framework-enabled vehicle **102**. Moreover, the interaction may be performed without requiring the personal devices **104** to have been paired with or be in communication with a head unit or other centralized computing platform of the vehicle **102**.

The vehicle **102** may include various types of automobile, crossover utility vehicle (CUV), sport utility vehicle (SUV), truck, recreational vehicle (RV), boat, plane or other mobile machine for transporting people or goods. In many cases, the vehicle **102** may be powered by an internal combustion engine. As another possibility, the vehicle **102** may be a hybrid electric vehicle (HEV) powered by both an internal combustion engine and one or more electric motors, such as a series hybrid electric vehicle (SHEV), a parallel hybrid electrical vehicle (PHEV), or a parallel/series hybrid electric vehicle (PSHEV). As the type and configuration of vehicle **102** may vary, the capabilities of the vehicle **102** may correspondingly vary. As some other possibilities, vehicles **102** may have different capabilities with respect to passenger capacity, towing ability and capacity, and storage volume.

The personal devices **104**-A, **104**-B and **104**-C (collectively **104**) may include mobile devices of the users, and/or wearable devices of the users. The mobile devices may be any of various types of portable computing device, such as cellular phones, tablet computers, smart watches, laptop computers, portable music players, or other devices capable of networked communication with other mobile devices. The wearable devices may include, as some non-limiting examples, smartwatches, smart glasses, fitness bands, control rings, or other personal mobility or accessory device designed to be worn and to communicate with the user's mobile device.

The in-vehicle components **106**-A through **106**-N (collectively **106**) may include various elements of the vehicle **102** having user-configurable settings. These in-vehicle components **106** may include, as some examples, overhead light in-vehicle components **106**-A through **106**-D, climate control in-vehicle components **106**-E and **106**-F, seat control in-vehicle components **106**-G through **106**-J, and speaker in-vehicle components **106**-K through **106**-N. Other examples of in-vehicle components **106** are possible as well, such as rear seat entertainment screens or automated window shades. In many cases, the in-vehicle component **106** may expose controls such as buttons, sliders, and touchscreens that may be used by the user to configure the particular settings of the in-vehicle component **106**. As some possibilities, the controls of the in-vehicle component **106** may allow the user to set a lighting level of a light control, set a temperature of a climate control, set a volume and source of audio for a speaker, and set a position of a seat.

The vehicle **102** interior may be divided into multiple zones **108**, where each zone **108** may be associated with a seating position within the vehicle **102** interior. For instance, the front row of the illustrated vehicle **102** may include a first zone **108**-A associated with the driver seating position, and a second zone **108**-B associated with a front passenger seating position. The second row of the illustrated vehicle **102** may include a third zone **108**-C associated with a driver-side rear seating position and a fourth zone **108**-D associated with a passenger-side rear seating position. Variations on the number and arrangement of zones **108** are possible. For instance, an alternate second row may include an additional fifth zone **108** of a second-row middle seating position (not shown). Four occupants are illustrated as being inside the example vehicle **102**, three of whom are using personal devices **104**. A driver occupant in the zone **108**-A is not using a personal device **104**. A front passenger occupant in the zone **108**-B is using the personal device **104**-A. A rear driver-side passenger occupant in the zone **108**-C is using the personal device **104**-B. A rear passenger-side passenger occupant in the zone **108**-D is using the personal device **104**-C.

Each of the various in-vehicle components **106** present in the vehicle **102** interior may be associated with the one or more of the zones **108**. As some examples, the in-vehicle components **106** may be associated with the zone **108** in which the respective in-vehicle component **106** is located and/or the one (or more) of the zones **108** that is controlled by the respective in-vehicle component **106**. For instance, the light in-vehicle component **106**-C accessible by the front passenger may be associated with the second zone **108**-B, while the light in-vehicle component **106**-D accessible by passenger-side rear may be associated with the fourth zone **108**-D. It should be noted that the illustrated portion of the vehicle **102** in FIG. **1**A is merely an example, and more, fewer, and/or differently located in-vehicle components **106** and zones **108** may be used.

Referring to FIG. **1**B, each in-vehicle component **106** may be equipped with a wireless transceiver **110** configured to facilitate detection of and identify proximity of the personal devices **104**. In an example, the wireless transceiver **110** may include a wireless device, such as a Bluetooth Low Energy transceiver configured to enable low energy Bluetooth signal intensity as a locator, to determine the proximity of the personal devices **104**. Detection of proximity of the personal device **104** by the wireless transceiver **110** may, in an example, cause a vehicle component interface application **118** of the detected personal device **104** to be activated.

In many examples the personal devices **104** may include a wireless transceiver **112** (e.g., a BLUETOOTH module, a ZIGBEE transceiver, a Wi-Fi transceiver, an IrDA transceiver, an RFID transceiver, etc.) configured to communicate with other compatible devices. In an example, the wireless transceiver **112** of the personal device **104** may communicate data with the wireless transceiver **110** of the in-vehicle component **106** over a wireless connection **114**. In another example, a wireless transceiver **112** of a wearable personal device **104** may communicate data with a wireless transceiver **112** of a mobile personal device **104** over a wireless connection **114**. The wireless connections **114** may be a Bluetooth Low Energy (BLE) connection, but other types of local wireless connection **114**, such as Wi-Fi or Zigbee may be utilized as well.

The personal devices **104** may also include a device modem configured to facilitate communication of the personal devices **104** with other devices over a communications network. The communications network may provide communications services, such as packet-switched network services (e.g., Internet access, VoIP communication services), to devices connected to the communications network. An example of a communications network may include a cellular telephone network. To facilitate the communications over the communications network, personal devices **104** may be associated with unique device identifiers (e.g., mobile device numbers (MDNs), Internet protocol (IP) addresses, identifiers of the device modems, etc.) to identify the communications of the personal devices **104** over the communications network. These personal device **104** identifiers may also be utilized by the in-vehicle component **106** to identify the personal devices **104**.

The vehicle component interface application **118** may be an application installed to the personal device **104**. The vehicle component interface application **118** may be configured to facilitate vehicle occupant access to features of the in-vehicle components **106** exposed for networked configuration via the wireless transceiver **110**. In some cases, the vehicle component interface application **118** may be configured to identify the available in-vehicle components **106**, identify the available features and current settings of the identified in-vehicle components **106**, and determine which of the available in-vehicle components **106** are within proximity to the vehicle occupant (e.g., in the same zone **108** as the location of the personal device **104**). The vehicle component interface application **118** may be further configured to display a user interface descriptive of the available features, receive user input, and provide commands based on the user input to allow the user to control the features of the in-vehicle components **106**. Thus, the system **100** may be configured to allow vehicle occupants to seamlessly interact with the in-vehicle components **106** in the vehicle **102**, without requiring the personal devices **104** to have been paired with or be in communication with a heat unit of the vehicle **102**.

To determine the in-vehicle components **106** that are in the same zone as the personal device **104**, the system **100** may use one or more device location-tracking techniques to identify the zone **108** in which the personal device **104** is located. Location-tracking techniques may be classified depending on whether the estimate is based on proximity, angulation or lateration. Proximity methods are "coarse-grained," and may provide information regarding whether a target is within a predefined range but they do not provide an exact location of the target. Angulation methods estimate a position of the target according to angles between the target and reference locations. Lateration provide an estimate of the target location, starting from available distances between target and references. The distance of the target from a reference can be obtained from a measurement of signal strength **116** over the wireless connection **114** between the wireless transceiver **110** of the in-vehicle component **106** and the wireless transceiver **112** of the personal device **104**, or from a time measurement of either arrival (TOA) or difference of arrival (TDOA).

One of the advantages of lateration using signal strength **116** is that it can leverage the already-existing received signal strength indication (RSSI) signal strength **116** information available in many communication protocols. For example, iBeacon uses the signal strength **116** information available in the Bluetooth Low-Energy (BLE) protocol to infer the distance of a beacon from a personal device **104** (i.e., a target), so that specific events can be triggered as the personal device **104** approaches the beacon. Other implementations expand on the concept, leveraging multiple references to estimate the location of the target. When the distance from three reference beacons are known, the location can be estimated in full (trilateration) from the following equations:

$$d_1^2=(x-x_1)^2+(y-y_1)^2+(z-z_1)^2$$

$$d_2^2=(x-x_2)^2+(y-y_2)^2+(z-z_2)^2$$

$$d_3^2=(x-x_3)^2+(y-y_3)^2+(z-z_3)^2 \quad (1)$$

In an example, as shown in FIG. **1**C, an in-vehicle component **106**-B may broadcast or otherwise send a request for signal strength **116** to other in-vehicle components **106**-A and **106**-C of the vehicle **102**. This request may cause the other in-vehicle components **106**-A and **106**-C to return wireless signal strength **116** data identified by their respective wireless transceiver **110** for whatever devices they detect (e.g., signal strength **116**-A for the personal device **104** identified by the wireless transceiver **110**-A, signal strength **116**-C for the personal device **104** identified by the wireless transceiver **110**-C). Using these signal strengths **116**-A and **116**-C, as well as signal strength **116**-B determined by the in-vehicle component **106**-B using its wireless transceiver **110**-B, the in-vehicle component **106**-B may use the equations (1) to perform trilateration and locate the personal device **104**.

However, use of signal strength **116** may require calibration of a known power at a known distance. As an example, the signal power received at a distance d from a transmitter can be calculated as an attenuation of a known power P_{d0} at a known distance d_0:

$$P_r = \frac{P_{(d_0)}}{(d/d_0)^n} \quad (2)$$

Notably, the path loss exponent n of equation (2) is a function of the environment. In dynamically changing environments, such as the interior of the vehicle **102**, the value of n is neither a known nor a fixed quantity. Moreover, many different approaches to estimating distance from the signal strength **116** in the presence of unknown environmental factors require significant computational processing power.

For instance, distance may be estimated from a signal strength **116** as follows, with constant A determined by calibration:

$$\text{RSSI (dBm)}=-10n \log 10(d)+A \quad (3)$$

As a function of distance, and for n in the 2-3 range, distance d may be approximated from the reference signal as follows:

$$d = 10\frac{RSSI}{20}k \quad (4)$$

Unless a calibration is performed, one may expect k to be within a certain range, but may be unable to extract a reasonably good estimate for the distance d.

An improved method of target location may provide information regarding in which zone **108** of the vehicle **102** a vehicle occupant is physically interacting with in-vehicle component **106**, as well as which personal device **104** is associated with the zone **108** occupant. As explained in detail herein, the method may be performed without distance estimates, while being robust with respect to interactions of personal devices **104** with in-vehicle components **106** located in close to equidistant location to multiple vehicle **102** occupants.

As shown in FIG. **1**A, the rear driver-side passenger is reaching for the seat control in-vehicle component **106**-H associated with the zone **108**-C. Responsive to the rear driver-side passenger reaching for the in-vehicle component **106**-H, the vehicle component interface application **118** installed to the personal device **104**-B may display a user interface descriptive of the available features or providing other information related to the in-vehicle component **106**-H. To do so however, the in-vehicle component **106**-H may be required to identify which of the personal devices **104** within the vehicle **102** interior is the personal device **104**-B of the user reaching for the in-vehicle component **106**-H. Based on that identification, the in-vehicle component **106**-H may notify the identified personal device **104**-B via wireless connection **114** to activate the vehicle component interface application **118**.

The mesh of in-vehicle components **106** and the personal devices **104** may be utilized to allow the in-vehicle components **106** to identify in which zone **108** each personal device **104** is located. As each of the in-vehicle components **106** is also associated with a zone **108**, the in-vehicle components **106** may accordingly identify the personal device **104** to be notified as being the personal device **104** that is associated with the same zone **108** with which the in-vehicle component **106**-H is associated. To continue the illustrated example, the vehicle component **106**-H may utilize the mesh of in-vehicle components **106** to determine which of the personal devices **104** is the personal device **104** associated with the zone **108**-C in which the vehicle component **106**-H is located (i.e., personal device **104**-B in the illustrated example).

As one possibility, the in-vehicle component **106**-H may utilize signal strength **116** data received from the personal devices **104** in the vehicle **102** to identify which of the personal devices **104** is in use by the occupant physically interacting with the seating controls in-vehicle component **106**-H. For instance, identifying the personal device **104** with the highest signal strength **116** at the in-vehicle component **106**-H would likely identify the correct personal device **104**-B, e.g., as follows:

$$\text{Personal Device} = i \Rightarrow \max_{i=1,n} RSSI_i \tag{5}$$

FIG. **2** illustrates an example system **200** including a vehicle occupant interacting with a centrally-located in-vehicle component **106**. In the example system **100**-A of FIG. **1**A, the vehicle occupant of the zone **108**-C is reaching for the seat control in-vehicle component **106**-H which is relatively distant from the other vehicle occupants. However, as compared to the example of FIG. **1**A, as shown in FIG. **2** the vehicle occupant in zone **108**-D is reaching for the climate control in-vehicle component **106**-F, which is located relatively centrally within the second row and within the vehicle **102** cabin generally.

The climate control in-vehicle component **106**-F may include multiple switches/sensors, e.g., a first set of controls configured to adjust vent, temperature, heated/cooled seat, or other settings for the driver-side second row passenger and a second set of controls to adjust vent, temperature, heated/cooled seat, or other settings for the passenger-side second row passenger. The climate control in-vehicle component **106**-F may be able to identify whether it was activated by select of controls for the driver-side rear zone **108**-C or the passenger-side rear zone **108**-D. but it may be unable to determine which of the personal devices **104** within the vehicle **102** is located within the zone controlled by the selected controls.

Moreover, the climate control in-vehicle component **106**-F may be unable to determine from maximum signal strength **116** using equation (5) which of the personal devices **104** within the vehicle **102** is the personal device **104** of the user utilizing the controls of the climate control in-vehicle component **106**-F. This may occur, as the climate control in-vehicle component **106**-F is not unambiguously closer in distance one of the personal devices **104** over others of the personal devices **104**. Other centrally-located in-vehicle components **106** may have similar issues, such as the speaker in-vehicle components **106**-K through **106**-N.

As an alternate approach, each of the personal devices **104** may attempt to identify which of the in-vehicle components **106** is closest to the respective personal device **104** by identifying to which of the in-vehicle components **106** the personal devices **104** provides the strongest signal strength **116**. Each of the personal devices **104** may accordingly set itself to be associated with the zone **108** of the in-vehicle component **106** identified as having the strongest signal strength **116** at the personal device **104**. However, such an approach may also provide incorrect or inconclusive results for cases in which the personal device **104** is relatively close to the center of the vehicle **102** or close to a zone **108** boundary, or for cases in which the signal strength **116** levels of the in-vehicle components **106** are un-calibrated with respect to one another.

To address these results, the personal devices **104** may be configured to determine an average signal strength **116** of the in-vehicle components **106** located within each zone **108**, and associate the personal device **104** with the zone **108** with which the personal device **104** has the highest average signal strength **116**. Accordingly, by considering the single strengths **116** of the in-vehicle components **106** by zone **108**, a more accurate determination of zone **108** association of the personal devices **104** may be performed.

FIG. **3** illustrates an example process **300** for using zone-coding of the in-vehicle components **106** to assign personal devices **104** to the zones **108** of the vehicle **102**. The process **300** may be performed, in an example, by one or more of the in-vehicle components **106** within the vehicle **102** cabin, in communication with others of the in-vehicle components **106** and one or more personal devices **104**. While the process **300** is described in terms of operation by one of the in-vehicle components **106**, it should be noted that a similar process **300** may be performed by the personal device **104** acquiring signal strength **116** information from the in-vehicle components **106** and performing the zone **108** assignment.

At operation **302**, the in-vehicle component **106** acquires signal strength **116** information from the personal devices **104**. In an example, the in-vehicle component **106** may broadcast or otherwise send a request for signal strength **116** to the other in-vehicle components **106** of the vehicle **102**. This request may cause the other in-vehicle components **106** to return wireless signal strength **116** data identified by their respective wireless transceiver **110** for the personal devices **104** that are detected.

At operation **304**, the in-vehicle component **106** identifies the zones **108** associated with the in-vehicle components **106**. In an example, each of the various in-vehicle components **106** present in the vehicle **102** interior may be associated with the one of the zones **108** in which the respective in-vehicle component **106** is located and/or the one (or more) of the zones **108** that is controlled by the respective in-vehicle component **106**. In some examples, the other in-vehicle components **106** may further provide the zone **108** information to the in-vehicle component **106**. In other examples, the in-vehicle component **106** may retrieve cached zone **108** information with respect to the zone **108** assignments of the in-vehicle components **106**.

At operation **306**, the in-vehicle component **106** calculates average signal strength **116** from the personal devices **104** according to zone **108**. In an example, for each of the personal devices **104** included in the signal strength **116** information, the in-vehicle component **106** may compute an average signal strength **116** of the personal device **104** as detected by the in-vehicle components **106** located within each zone **108**.

At operation **308** the in-vehicle components **106** associates the personal device **104** with the zone **108** that maximizes the average signal strength **116**. In an example, if the personal device **104**-A is determined to have the highest signal strength **116** to the in-vehicle components **106** in the zone **108**-B, then the personal device **104**-A may be associated with the zone **108**-B. In another example, if the personal device **104**-B is determined to have the highest signal strength **116** to the in-vehicle components **106** in the zone **108**-C, then the personal device **104**-B may be associated with the zone **108**-C. Accordingly, by using average signal strength **116** information of the personal devices **104** across the zones **108**, the in-vehicle component **106** may be able to assign the personal devices **104** to zones **108** more accurately than if signal strength **116** data from a single in-vehicle component **106** were used. After operation **308**, the process **300** ends.

FIG. **4** illustrates an example process **400** for activating the personal device **104** associated with the zone **108** of the in-vehicle component **106** with which a user is interacting. The process **400** may be performed, in an example, by one of the in-vehicle components **106** within the vehicle **102** cabin.

At operation **402**, the in-vehicle component **106** determines whether the user has interacted with the in-vehicle component **106**. In an example, the in-vehicle component **106** may receive user input to the set of controls of the in-vehicle component **106** configured to receive input from the user with respect to basic or core functions of the in-vehicle component **106** (e.g., turn light on/off, turn speaker on/off, etc.). In another example, the in-vehicle component **106** may identify an increase in wireless signal strength **116** of a personal device **104** to the wireless transceiver **110**. If a user interaction with the in-vehicle component **106** is detected control passes to operation **404**. Otherwise the process **400** remains at operation **402**.

At operation **404**, the in-vehicle component **106** performs zone **108** association of the personal devices **104** within the vehicle **102**. In an example, the zone **108** association may be performed using a process such as the process **300** described in detail above. In other examples, the in-vehicle component **106** may use a previously-determined zone **108** association of the personal devices **104**, e.g., computed for a prior user interaction with the in-vehicle component **106** or with another of the in-vehicle components **106**.

At operation **406**, the in-vehicle component **106** identifies the personal device **104** associated with the zone **108** of the in-vehicle component **106**. In an example, the in-vehicle components **106** may be associated with the one of the zones **108** in which the in-vehicle component **106** is located and/or the one (or more) of the zones **108** that is controlled by the in-vehicle component **106**. Using the zone **108** of the in-vehicle component **106**, the in-vehicle component **106** may look up or otherwise identify which of the personal devices **104** is associated with the same zone **108** as with which the in-vehicle component **106** is associated.

At operation **408**, the in-vehicle component **106** sends a notification to the identified personal device **104**. In an example, the in-vehicle component **106** utilize the wireless transceiver **110** of the in-vehicle component **106** to notify the identified personal device **104** via wireless connection **114** to activate the vehicle component interface application **118**. After operation **408**, the process **400** ends.

It should be noted that the lateration process **300** using "zone-coding" is only one example, and variations are possible. As a possibility, in some examples one or more of the in-vehicle components **106** may not be uniquely associated with just one seat or zone **108**. For instance, one or more of the in-vehicle components **106** may be shared among two or more passengers sharing the same vehicle **102** row. In such an example, the in-vehicle component **106** may be coded as belonging to multiple zones **108**. As one example, an in-vehicle component **106** central to the second row may be associated with zones **108**-C and **108**-D. When physical interaction is detected with an in-vehicle component **106** associated with multiple zones **108**, if personal devices **104** are detected in more than one of the associated zones **108**, a decision will need to be made whether to notify both in-vehicle components **106**, neither of the in-vehicle components **106**, or one of the in-vehicle components **106**, e.g., based a history of past interactions.

In sum, by using a zone-coding of the in-vehicle components **106**, and signal strength **116** information that is already available in many communication protocols, the in-vehicle components **106** may be able to assign zones **108** to personal devices **104** included within the vehicle **102**. By using the zone **108** assignments of the in-vehicle components **106** and personal devices **104**, one of the in-vehicle components **106** receives an indication of a user interaction with its controls, the in-vehicle component **106** may easily send a notification to the personal device **104** that is associated with the same zone **108** as the in-vehicle component **106** with which the user is interacting, thereby allowing the correct personal devices **104** to control the features of the in-vehicle components **106**.

Computing devices described herein, such as the personal devices **104** and in-vehicle components **106**, generally include computer-executable instructions, where the instructions may be executable by one or more computing devices such as those listed above. Computer-executable instructions may be compiled or interpreted from computer programs created using a variety of programming languages and/or technologies, including, without limitation, and either alone or in combination, Java™, C, C++, C#, Visual Basic, Java Script, Perl, etc. In general, a processor (e.g., a microprocessor) receives instructions, e.g., from a memory, a computer-readable medium, etc., and executes these instructions, thereby performing one or more processes, including one or more of the processes described herein. Such instructions and other data may be stored and transmitted using a variety of computer-readable media.

With regard to the processes, systems, methods, heuristics, etc., described herein, it should be understood that, although the steps of such processes, etc., have been described as occurring according to a certain ordered sequence, such processes could be practiced with the described steps performed in an order other than the order described herein. It further should be understood that certain steps could be performed simultaneously, that other steps could be added, or that certain steps described herein could be omitted. In other words, the descriptions of processes herein are provided for the purpose of illustrating certain embodiments, and should in no way be construed so as to limit the claims.

While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention. Additionally, the features of various implementing embodiments may be combined to form further embodiments of the invention.

What is claimed is:

1. A system comprising:

vehicle seating having zones associated with seating positions; and

in-vehicle components, each associated with at least one of the zones, each zone including a plurality of in-vehicle components, one of the in-vehicle components programmed to

identify a personal device associated with the zone of the in-vehicle component by determining average signal strength between the personal device and the plurality of in-vehicle components of each zone, and identifying for which zone the average signal strength of the respective plurality of in-vehicle components is highest, and

send a notification to the personal device responsive to a detected user interaction.

2. The system of claim **1**, wherein the notification is configured to cause the personal device to invoke a vehicle component interface application to display a user interface for the in-vehicle component using the personal device.

3. The system of claim **1**, wherein the zones include a first zone associated with a driver seating position, a second zone associated with a front passenger seating position, a third zone associated with a driver-side rear seating position, and a fourth zone associated with a passenger-side rear seating position.

4. The system of claim **3**, wherein the zones further include a fifth zone associated with a driver-side third-row seating position, and a sixth zone associated with a passenger-side third-row seating position.

5. The system of claim **1**, wherein the personal device includes one or more of a cellular telephone, a tablet computer, a smart watch, a laptop computer, a portable music player, a smartwatch, smart glasses, a fitness band, and a control ring.

6. The system of claim **1**, wherein the detected user interaction includes receipt of user input to a set of user interface controls of the in-vehicle component.

7. The system of claim **1**, wherein the in-vehicle component includes a wireless transceiver, and the detected user interaction includes identifying an increasing wireless signal intensity of a personal device to the wireless transceiver.

8. The system of claim **1**, wherein the one of the in-vehicle components is further programmed to:

acquire wireless signal strength intensity information for personal devices from other of the in-vehicle components of the vehicle;

identify zones of the in-vehicle components;

calculate an average signal strength of the personal device to the in-vehicle components in each of the zones; and

associate the personal device with the zone having a highest average signal strength to the personal device.

9. A system comprising:

an in-vehicle component, associated with a zone seating position of a vehicle, programmed to

acquire wireless signal strength intensity information of a personal device from other in-vehicle components;

identify zones of the other in-vehicle components, each zone including a plurality of in-vehicle components;

for each of the zones, calculate an average signal strength of the personal device to the in-vehicle components in the zone; and

associate the personal device with the zone having a highest average signal strength to the personal device.

10. The system of claim **9**, wherein each of the zones is associated with a respective seating position of the vehicle.

11. The system of claim **10**, wherein the zones include a first zone associated with a driver seating position, a second zone associated with a front passenger seating position, a third zone associated with a driver-side rear seating position, and a fourth zone associated with a passenger-side rear seating position.

12. The system of claim **9**, wherein the personal device is a cellular telephone.

13. The system of claim **9**, wherein the in-vehicle component is further programmed to query other of in-vehicle components for the wireless signal strength intensity information of the personal device responsive to a detected user interaction.

14. The system of claim **13**, wherein the detected user interaction includes receipt of user input to a set of user interface controls of the in-vehicle component.

15. A computer-implemented method comprising:

detecting user interaction to an in-vehicle component of a zone;

acquiring signal strength intensity information of personal devices from other in-vehicle components of the zone;

calculating average signal strengths of the personal devices to the in-vehicle components;

associating one of the personal devices to the zone as having a highest average signal strength to the in-vehicle components of the zone; and

sending a notification to the one of the personal devices.

16. The method of claim **15**, further comprising associating each of respective seating position of the vehicle with a respective zone.

17. The method of claim **15**, wherein the notification includes information requesting a vehicle component interface application to display a user interface for the in-vehicle component using the personal device.

18. The method of claim **15**, wherein the personal device includes one or more of a cellular telephone, a tablet computer, a smart watch, a laptop computer, a portable music player, a smartwatch, smart glasses, a fitness band, and a control ring.

19. The method of claim **15**, wherein the user interaction includes receiving user input to a set of user interface controls of the in-vehicle component.

20. A system comprising:

a memory; and

a processor programmed to:

for each seating zone of a vehicle, identify a plurality of in-vehicle components associated with the zone and average signal strength between the personal device and the plurality of in-vehicle components of the zone,

identify for which zone the average signal strength is highest, and

receive a notification responsive to a user interaction detected by one of the in-vehicle components of the zone.

* * * * *